Evaluation of medication-related clinical decision support alert overrides in the intensive care unit

Wong, Adrian ; Amato, Mary G ; Seger, Diane L ; Slight, Sarah P ; Beeler, Patrick E ; Dykes, Patricia C ; Fiskio, Julie M ; Silvers, Elizabeth R ; Orav, E. John ; Eguale, Tewodros ; Bates, David W

Abstract: Purpose: Medication-related clinical decision support (CDS) has been identified as a method to improve patient outcomes but is historically frequently overridden and may be inappropriately so. Patients in the intensive care unit (ICU) are at a higher risk of harm from adverse drug events (ADEs) and these overrides may increase patient harm. The objective of this study is to determine appropriateness of overridden medication-related CDS overrides in the ICU. Materials and methods: We evaluated overridden medication-related alerts of four alert categories from January 2009 to December 2011. The primary outcome was the appropriateness of a random sample of overrides based on predetermined criteria. Secondary outcomes included the incidence of adverse drug events (ADEs) that re-sulted from the overridden alert. Results: A total of 47,449 overridden alerts were included for evaluation. The appropriateness rate for overridden alerts varied by alert category (allergy: 94%, drug-drug interaction: 84%, geriatric: 57%, renal: 27%). A total of seven actual ADEs were identified in the random sample and where the medication(s) was administered (n = 366), with an increased risk of ADEs associated with inappropriately overridden alerts (p = 0.0078). Conclusions: The appropriateness of medication-related clinical decision support overrides in the ICU varied sub-stantially by the type of alert. Inappropriately overridden alerts were associated with an increased risk of ADEs compared to appropriately overridden alerts.

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Adrian Wong, PharmD[1,2]
Mary G. Amato, PharmD, MPH[1,2]
Diane L. Seger, RPh[1,3]
Sarah P. Slight, MPharm, PhD, PGDip[1,4]
Patrick E. Beeler, MD[1,6,7]
Patricia C. Dykes, PhD, RN, FACMI[1,7]
Julie M. Fiskio, BS[1,3]
Elizabeth R. Silvers, BA[1,3]
E. John Orav, PhD[8]
Tewodros Eguale, MD, PhD[1,2]
David W. Bates, MD, MSc[1,7]

[1]The Center for Patient Safety Research and Practice, Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, Boston, MA, USA

[2]MCPHS University, Boston, MA, USA

[3]Partners HealthCare, Wellesley, Boston, MA, USA

[4]School of Medicine, Pharmacy and Health, The University of Durham, Stockton on Tees, Durham, UK

[5]Newcastle upon Tyne Hospitals NHS Foundation Trust, Newcastle, United Kingdom

[6]Research Center for Medical Informatics, University Hospital, Zurich, Switzerland

[7]Harvard Medical School, Boston, MA, USA

[8]Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA, USA

Corresponding author:

David Bates, MD, MSc
Senior Vice President
Chief Innovation Officer
Chief, Division of General Internal Medicine and Primary Care
Brigham and Women's Hospital
1620 Tremont Street
75 Francis Street
Boston, MA 02115
Phone: 617-732-5650
Fax: 617-732-7072
Email: dbates@partners.org

Disclosures

Dr. Bates reported receiving equity from Intensix, which makes software to support clinical decision-making in intensive care; being named as coinventor on patent No. 6029138 held by Brigham and Women's Hospital on the use of decision support software for medical management, licensed to the Medicalis Corporation, and holding a minority equity position in Medicalis, which develops web-based decision support for radiology test ordering; consulting for EarlySense, which makes patient safety monitoring systems; receiving equity and cash compensation from QPID Inc, a company focused on intelligence systems for electronic health records; receiving cash compensation from CDI (Negev) Ltd, which is a not-for-profit incubator for health IT startups; receiving equity from Enelgy, which makes software to support evidence-based clinical decisions, from Ethosmart, which makes software to help patients with chronic diseases, and from MDClone, which takes clinical data and produces deidentified versions of it. The remaining authors have disclosed that they do not have any conflicts of interest.

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ABSTRACT

Purpose: Medication-related clinical decision support (CDS) has been identified as a method to improve patient outcomes but are historically frequently overridden and may be inappropriately so. Patients in the intensive care unit (ICU) are at a higher risk of harm from adverse drug events (ADEs) and these overrides may increase patient harm. The objective of this study is to determine appropriateness of overridden medication-related CDS overrides in the ICU.

Materials and Methods: We evaluated overridden medication-related alerts of four alert categories from January 2009 to December 2011. The primary outcome was the appropriateness of a random sample of overrides based on predetermined criteria. Secondary outcomes included the incidence of adverse drug events (ADEs) that resulted from the overridden alert.

Results: A total of 47,449 overridden alerts were included for evaluation. The appropriateness rate for overridden alerts varied by alert category (allergy: 94%, drug-drug interaction: 84%, geriatric: 57%, renal 27%). A total of seven actual ADEs were identified in the random sample and where the medication(s) was administered (n = 366), with an increased risk of ADEs associated with inappropriately overridden alerts (p = 0.0078).

Conclusions: The appropriateness of medication-related clinical decision support overrides in the ICU varied substantially by the type of alert. Inappropriately overridden alerts were associated with an increased risk of ADEs compared to appropriately overridden alerts.

Keywords: Adverse drug event; clinical decision support; critical care; patient safety; quality of care

INTRODUCTION

Clinical decision support (CDS) aims to improve health care by enhancing decision-making in both inpatient and outpatient settings. Medication-related CDS can assist users when ordering medications and provide potential warnings regarding ordered therapy. Despite evidence to support the benefits of CDS in reducing adverse drug events (ADEs), costs, hospital length of stay and patient morbidity and mortality, there is also a growing body of evidence detailing how these alerts or warnings are regularly overridden. [1-4] The incidence of alert overriding is high in the outpatient setting, as demonstrated by an override rate of 52.6 per 100 alerts. [3,4] Only 53% of these overrides were identified as appropriate, defined as a false positive alert (i.e., an alert that was not clinically relevant to the patient). In a Veterans Affairs population, one study found that the override rate of critical alerts was 87%. [5] Explanations for overrides include poorly constructed alerts and alert fatigue. [4] However, CDS overrides may lead to a spectrum of patient harm from no harm to irreversible harm. ADEs have been associated with additional healthcare costs, increased hospital length of stay, and increased mortality. [6-9] However, literature associating CDS overrides with increased patient harm is limited. [10-11]

Patients in the intensive care unit (ICU) are particularly susceptible to ADEs. These patients may be at greater risk than general ward patients for a variety of reasons, including altered pharmacokinetics, an increased length of stay and an increased number of medications administered. [12-16] Continuation of a patient's home medications may also be a potential cause of ADEs, given a patients altered pharmacokinetics. Prospective cohort studies identifying ADEs in the ICU found them to be common, with rates varying from 30.6 to 96.5 per 1,000 patient days, associated with morbidity but not associated with increased mortality. [17,18]

Given the benefits of CDS, overrides of available alerts may lead to increased risk of patient harm in the ICU.

However, few studies exist evaluating the appropriateness of CDS alert overrides in inpatients and we could not identify previous studies evaluating overrides in intensive care. Therefore, we performed a study to characterize the appropriateness of CDS overrides in the ICU, including their potential association with harm.

MATERIALS AND METHODS

This study was a retrospective, observational study evaluating medication-related CDS alert overrides by providers. Alert overrides were generated between January 2009 and December 2011 from patients admitted to an adult ICU at Brigham and Women's Hospital. The alerts targeted were focused on alert types that have a high occurrence and significance in the ICU patient population: drug-allergy, drug-drug interaction (DDI), geriatric (age ≥ 65 years) and renal (creatinine clearance calculated by the Cockcroft-Gault equation). [19] The proprietary Partners Healthcare System Knowledge Base was used as the basis of the DDI, geriatric and renal alerts, which had been customized over years based on end-user feedback and prospective review of literature. [20,21] Allergy alert logic was sourced from First DataBank (First DataBank, South San Francisco, CA, USA).

A few alerts occurred very frequently and overrides were generally considered appropriate, and these were excluded and therefore considered the "unevaluated" alerts. These were as follows:

- DDI – epidural bupivicaine and anticoagulants ordered appropriately per institution policy, limited systemic absorption, intravenous calcium and

ceftriaxone alerts which were intended to fire only in neonatal patients, and alerts involving absorption issues, but with a medication ordered in a parenteral form;

- Geriatric – short-term laxative use;
- Renal – aspirin dosed for cardioprotection (defined as ≤325 mg daily). [22]

The primary outcome was the appropriateness of the remaining overrides, assessed by two independent reviewers with a set of predetermined criteria specific for each type of alert. Secondary outcomes included the documented reason for override and the incidence of ADEs associated with overrides. Outcome evaluation was only completed on the "evaluated alerts" (i.e. alerts that were not excluded as they could be appropriate or inappropriate). This study was approved by the Partners Institutional Review Board.

Appropriateness Evaluation

Criteria for appropriateness were created via previously published data, including guidelines, as well as clinical experience of a multidisciplinary group. [23] Criteria were specific for alert categories and modified until a consensus was reached for all criteria. A random sample of 100 evaluated alerts (termed "random sample") in each of the alert categories was selected for determination of appropriateness. Two clinical pharmacists independently evaluated the appropriateness of overrides. The inter-rater agreement for appropriateness was determined via a κ statistic. Disagreements were resolved via discussion between the two independent reviewers. If consensus was not achieved, a third experienced reviewer was consulted. The κ for the criteria agreement of appropriateness was 0.79 (95% CI 0.73-0.86) indicating substantial agreement, with a percent agreement of 90.6%.

Override Rationale Evaluation

A rationale for overriding the alert was required to be provided only for allergy and DDI alerts; override reasons for geriatric and renal medication alerts were optional. Rationale was grouped based on choice from a drop-down menu (i.e. coded reasons), while related free-text entries were grouped together based on patterns. These system-coded reasons were available in the data for evaluation. The override reason, if provided, was also utilized in the appropriateness evaluation (e.g. if a prescriber gave the reason 'will monitor as recommended,' then the medical record was evaluated for related monitoring).

ADE Evaluation

To evaluate for ADEs, we performed patient chart reviews on the random sample of overrides (n = 400). In 366 cases, the patient actually received the medication. ADEs were specific to the overridden alert (e.g. amiodarone and levofloxacin DDI, only evaluating QTc and documentation of dysrrhythmia). Data relevant to an ADE, such as patient comorbidities, laboratory reports, medication orders and patient notes documented by nurses or providers, were abstracted and summarized by one reviewer. These data were blinded (i.e. appropriateness of override was not provided) and forwarded to two independent reviewers to determine if an ADE occurred (no ADE, probable ADE, definite ADE), the severity of the ADE (significant, serious, life-threatening, fatal) and whether it was considered preventable (non-preventable, preventable). If consensus was not achieved, a third experienced reviewer was consulted. ADEs of inappropriately overridden alerts were defined as preventable, as there was a CDS alert that could have prevented the medication from being ordered. Study personnel had undergone training based on curriculum developed by the Center for Excellence for Patient Safety Research at Brigham and Women's Hospital. This training has been used in previous studies and has been previously described. [24]

Statistical Analysis

Descriptive statistics were used to summarize patient and alert characteristics. A chi-square or Fisher's exact test was used to compare categorical variables. An exact binomial calculation was used to determine confidence intervals within the observed samples. Approximate binomial confidence intervals were calculated for the weighted population average ADE rates in appropriately and inappropriately overridden alerts. Because observed ADE rates of 0 in some categories would underestimate the variances, the population weighted rate was used instead. Both an exact Fisher test and an exact Poisson regression, adjusted for alert categories, were used to compare the rates of ADEs between the appropriately and inappropriately overridden alerts in the random sample. A p-value of < 0.05 was considered significant. Statistical analysis was completed using SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

RESULTS

A total of 59,175 overridden medication-related alerts were fired for patients who were admitted to the ICU between January 2009 and December 2011. A total of 47,449 alerts (80.2%) were considered in our evaluated sample for appropriateness (Figure 1), and, unless otherwise noted, constitute the analysis sample. Allergy alerts accounted for the majority of CDS overrides (84.4%).

There were a total of 4,776 unique patient encounters overall in the study population (Table 1). Patients with overridden geriatric and renal alerts tended to be older than in the other groups, as expected. Patients were primarily located in the cardiac surgery or medical ICUs at the time of alert override.

The three most common triggering medication(s) alerted in each of the different types of alerts and the route of administration are described in Table 2. There were a total of 4,502 unique overridden patient-allergy alerts (i.e. one unique allergy record per patient) (11.2%). The three most common reactions to the allergen were 'unknown' (n = 1,264, 28.1%), 'rash' (n = 562, 12.5%) and 'GI upset' (n = 398, 8.8%). The three most common reasons given for overriding allergy alerts were 'patient has taken previously without allergic reaction/patient has tolerated previously' (n = 20,514, 51.2%), 'physician aware' (n = 7,729, 19.3%) and 'low risk cross sensitivity will monitor' (n = 5,128, 12.8%). A total of 194 unique DDI alerts (i.e., unique medication combinations) were overridden in our evaluation. Regarding categories of DDI alerts overridden using the whole sample, alerts indicating an increased risk of QTc prolongation (n = 1,194, 30.8%) was most common, with alerts regarding myopathy (n = 885, 22.8%) and risk of altered medication levels, such as digoxin (n = 666, 17.2%), also being relatively common. The three most common override reasons were 'will monitor as recommended' (n = 1,911, 49.3%), 'will adjust dose as recommended' (n = 522, 13.5%) and 'patient has already tolerated combination' (n = 418, 10.8%). A total of 58 unique medications were overridden in the geriatric alerts, while only nine unique medications were overridden in the renal alert category.

Table 3 details findings on the appropriateness of overrides, as well as the number of overrides that were related to documented home medication and their associated appropriateness. The incidence of appropriateness varied significantly by alert category ($p<0.001$). The weighted appropriateness for all alerts (unevaluated and evaluated alerts) was 92.3%. Of the 138 inappropriately overridden alerts, 117 (84.8%) of the associated medication(s) were administered to the patient. The renal alerts were most frequently linked to an inappropriate override where the associated medication was not administered to the patient (n = 18, 85.7%). The most common

medications associated with an inappropriate override for the allergy, DDI, geriatric, and renal alert categories were cefazolin (n = 2, 33.3%), simvastatin (n = 7, 43.8%), clonazepam (n = 11, 25.6%), and hydrochlorothiazide (n = 32, 43.8%). Table 4 details the number of overrides per patient encounter and the number of unique overrides per patient encounter.

A total of 366 overrides (91.5%) from the random sample were evaluated for ADEs in the medical record as they resulted in medication(s) administration to the patient. A total of seven ADEs were identified (1.9% of random sample alert overrides) and most were from inappropriately overridden alerts (n = 6, 85.7%). The rate of ADEs per 100 overridden alerts for the appropriately and inappropriately overridden alerts were 0.091 (95% CI 0.036-0.146) and 11.06 (95% CI 5.62-16.50), respectively. The proportion of ADEs per alert category and appropriateness of override are provided in Table 5, including 95% confidence intervals. Details of the ADEs identified are located in Table 6, such as the type of alert, alert and clinical scenario details, where the ADE occurred (i.e., in the ICU or on the general ward/floor) and the ADE classification. Inappropriately overridden alerts had a significantly higher incidence of ADEs (6 ADEs in 138 overridden alerts) than appropriately overridden alerts (1 in 262) overall (p=0.0078), although the difference did not reach significance in any specific category because of the small sample sizes. A Poisson comparison using ADE rates, adjusted for the individual alert categories, also found similar results (p = 0.011).

DISCUSSION

We evaluated the appropriateness of medication-related CDS overrides in the ICU and potential harm associated with such actions. The appropriateness varied significantly by the type of alert and location where allergy overrides were commonly appropriately overridden. Renal alerts were commonly inappropriately overridden. Inappropriate overrides were associated with

an increased risk of ADEs. Appropriateness rates differed slightly from the published literature; however, this is likely due to the alert types studied and the close monitoring in the ICU, which affected our appropriateness criteria. [4,5,20]

The CDS at our institution has been continuously modified over the years, with previously documented success. [20,21] This CDS has been tailored to decrease the number of non-pertinent alerts; however, we believe it should be possible to decrease the override rate further by turning off more of the relatively unimportant warnings. [25,26] In the future, alerts regarding recommended medications and doses should take into account patient context and include multiple patient-specific factors of concern. [26] We believe that allowing providers to control which alerts they can see would lead to problems, as studies demonstrate a significant positive correlation between the number of overridden alerts and the number of providers recommending alerts to be turned off. [27]

The finding that almost all allergy overrides were appropriately overridden indicates that this is an area that needs improvement with respect to specificity, especially given the large amount of CDS overrides that allergy alerts accounted for. This is compounded by the finding that the majority of allergy overrides were for the documented reason that the patient had previously tolerated the medication; therefore, perhaps such alerts should be turned off if this is known to be the case. Eliminating the duplicative nature of these alerts should be a focus in improving the effectiveness of this type of CDS alert. If a provider has to override the same allergy alert for a specific patient nine times, this represents a problem which is wasting provider time and contributing to alert fatigue. In an evaluation of the allergy database at our institutions, 44.5% of allergy reactions were non-immune-mediated. [28] Given the high incidence of overrides at our institution involving opioid ‘allergies’ documented with a reaction of

gastrointestinal intolerance, this is clearly an area with opportunity for improvement. [29,30] Additionally, exact versus non-exact matches of documented allergy and ordered medication and associated cross-sensitivity may also need to be considered. The allergy CDS alerts for all patients who had their home medication continued were determined to have been appropriately overridden. These alerts could probably be safely suppressed or a reminder for the provider to remove the documented allergy, if appropriate.

Characteristics of the overridden DDI and geriatric alerts do not seem especially surprising. Given the constant monitoring of ICU patients, overrides were largely appropriate. However, this degree of monitoring may give a false sense of security given the severity of some interactions. [27] The types of medications involved for both alerts were expected, as the alerts were triggered by the medications most commonly used. A potential explanation for the disproportionate number of males in the DDI population is regarding the common medications and the increased risk of atrial fibrillation and coronary heart disease in males. [31,32] Regarding two of the most common types of DDIs, one study indicated that interactions involving medications that are QTc-prolonging or increase the risk of myopathy were unanimously voted by providers not to be turned off. [27] Additionally, one pre-post intervention study involving CDS in the ICU and QTc-prolonging DDIs found a decrease in related ADEs by 64%. [33]

The low appropriateness rate of overridden renal alerts was a finding consistent with other published literature. [4] One proposed explanation is the ICU population is at high risk of acute kidney injury (AKI). This develops in approximately one-quarter of hospitalized patients; however, it is even more common in the ICU, with rates up to 60%. [34] Home medications were continued in one-third of patients, triggering a renal alert which was overridden. This override frequency was surprising. Home medications should be carefully scrutinized in the ICU because

of the potential for profound metabolic disturbances. Given the various alternative options available for many medications (i.e., furosemide for hydrochlorothiazide, insulin for glyburide), this was a surprising finding that safer and/or more effective alternative options were not used.

The rate of ADEs associated with overrides may appear low relative to other published data including total ADE rates. [16-18] However, this was related to the study design, which limited ADE review to the override alerts for which the related medication was administered to the patient. Based on our appropriateness evaluation, inappropriate overrides accounted for approximately 10% of overrides in the ICU. The heavy weighting provided by the allergy overrides due to their high number and high prevalence of appropriateness heeds caution in interpretation as the appropriateness rate varied significantly by alert category. Inappropriate overrides likely account for a large portion of ordered medications, especially those related to renal alerts, in the ICU. Additionally, interpretation of the 95% confidence intervals may be affected by the low rate of ADEs in our study.

Some methods that may serve to improve available CDS are as follows: for allergies, differentiation of alerts based on true allergy versus medication intolerance and how the information is presented [30]; for DDIs, incorporation of monitoring (e.g., levels) into the CDS alert when the documented reason for override involves ‘will monitor’ [35]; for renal alerts, incorporation of a method to determine if the patient has AKI (e.g. trend in serum creatinine, if recent data is available). Early detection of AKI would be of most benefit, although data supporting CDS remains controversial. [36] Finally, it may be useful to inform providers that overrides and their documented reason for override are being evaluated. [37]

Our study had several limitations. First, this study was completed at a single-center. As our institution has continually aimed to improve our internally-developed medication-related

CDS, it had already been tailored and differed from that in the broader marketplace. Application to commercial databases may be limited, as the number of alerts in our database is likely smaller than other available databases. Second, this was a retrospective evaluation, which limited the determination of appropriateness and ADEs to the extent of documentation. Therefore, this is likely an underestimate of the actual amount of ADEs associated with these overrides. However, this study details the methods and provides a baseline estimate of override rates in the ICU. Additionally, our random sample was biased towards those patients who had multiple overrides, as they would have a higher chance to be included. Potentially, the higher number of overrides may be because those alerts were not clinically relevant and therefore, appropriately overridden. Finally, the appropriateness rate is also only applicable to overrides and not at a patient level, as this was not evaluated in our study. Future work in additional centers is warranted to validate rates in ICUs with commercial CDS databases. Although inappropriately overridden alerts were associated with an increased risk of ADEs, our study design prevents evaluation of causality. Third, alert fatigue may have resulted in providers selecting override reasons on allergy and DDI alerts that were not truly reflective of the rationale motivating their actions. Findings from evaluation of overrides in the primary care setting indicated that only approximately 35% of DDI alert overrides with an override reason of 'will monitor as recommended' actually had monitoring performed. [38]

CONCLUSIONS

We evaluated the appropriateness of medication-related CDS overrides in the ICU, and found that approximately 92% were appropriate, based on the weighted numbers. Given the high complexity of ICU patients, it is important to learn how CDS affects outcomes in this population. We identified a number of alerts that could likely be safely suppressed. Future studies should

validate rates in additional centers, define the “optimal” override rate in this population, examine how CDS can be made more patient-specific, and how CDS alerts affect patient outcomes in the ICU.

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Tables

Table 1. Demographics of Unique Patients Encounters					
	Allergy (n = 2934)	DDI (n = 1230)	Geriatric (n = 1332)	Renal (n = 65)	Total (n = 4776)
Age, y, mean±SD	63.3±15.6	64.0±15.0	71.7±7.4	73.0 (63.5,83.0)*	65.4±14.8
Male, n (%)	1209 (41.2)	730 (59.3)	689 (51.7)	27 (44.3)	2320 (48.6)
Type of ICU, n (%)					
Burn	192 (6.5)	99 (8.0)	92 (6.9)	8 (12.4)	274 (5.7)
Cardiac Surgery	1061 (36.2)	383 (31.1)	474 (35.6)	22 (33.8)	1668 (34.9)
Coronary	286 (9.7)	198 (16.1)	128 (9.6)	11 (16.9)	554 (11.6)
Medical	963 (32.8)	381 (31.0)	388 (29.1)	14 (21.5)	1544 (32.3)
Neurology	113 (3.9)	41 (3.4)	73 (5.5)	2 (3.1)	212 (4.4)
Surgical	126 (4.3)	28 (2.3)	78 (5.9)	5 (7.7)	149 (3.1)
Thoracic	193 (6.6)	100 (8.1)	99 (7.4)	3 (4.6)	375 (8.0)

* Median (IQR)
DDI = drug-drug interaction, ICU = intensive care unit

Table 2. Characteristics of Overridden Alerts by Category with Top 3 Triggering Medications				
	Allergy (n = 40056)	DDI (n = 3877)	Geriatric (n = 3414)	Renal (n = 102)
Enteral route, n (%)	18515 (46.3)	4365 (56.3)*	2973 (87.1)	76 (74.5)
Top 3 triggering medication(s), (n, %)				
1.	Penicillins (7330, 18.3)	Amiodarone, levofloxacin (303, 7.8)	Oxycodone and acetaminophen (663, 19.4)	Hydrochlorothiazide (43, 42.2)
2.	Codeine (4526, 11.3)	Amiodarone, digoxin (291, 7.5)	Clonazepam (517, 15.1)	Ketorolac (20, 19.6)
3.	Morphine (2964, 7.4)	Diltiazem, simvastatin (256, 6.6)	Alprazolam (437, 12.8)	Ibuprofen (10, 9.8)

* Accounts for both medications in interaction
DDI = drug-drug interaction

Table 3. Appropriateness of Overridden Alerts				
	Allergy (n = 100)	DDI (n = 100)	Geriatric (n = 100)	Renal (n = 100)
Appropriate, n (%)	94 (94.0)	84 (84.0)	57 (57.0)	27 (27.0)
Home medication, n (%)	10 (10.0)	36 (36.0)	40 (40.0)	46 (46.0)
Appropriate home medication, n (% of total home medication)	10 (100.0)	28 (77.8)	29 (72.5)	11 (23.9)

DDI = drug-drug interaction

Table 4. Numbers of Overridden Alerts per Patient Encounter				
	Allergy	DDI	Geriatric	Renal
Overrides per patient encounter, median n (IQR) (Range)	6 (2, 12) (1-660)	1 (1, 2) (1-32)	2 (1, 3) (1-25)	1 (1,2) (1-5)
Unique overrides per patient encounter, median n (IQR) (Range)	4 (2, 9) (1-325)	2 (1, 4) (1-32)	2 (1, 3) (1-25)	1 (1,2) (1-4)

DDI = drug-drug interaction; IQR = interquartile range

Table 5. Adverse Drug Events per Alert Category and Appropriateness				
	Allergy	DDI	Geriatric	Renal
Appropriate, % (95% CI)	0 (0, 4.1)	1.4 (0.36, 17.0)	0 (0, 6.3)	0 (0, 14.2)
Inappropriate, % (95% CI)	16.7 (0.4, 64.1)	0 (0, 21.8)	7.1 (1.4, 18.3)	3.6 (0.4, 11.9)

DDI = drug-drug interaction

Table 6. Adverse Drug Events Occurring after Alert Override

Type of Alert	Alert and Clinical Scenario Details	Classification
Drug-drug interaction	• Amiodarone – levofloxacin • QTc prolongation • Override reason: "Will monitor as recommended" • Increase in QTc from 448 to 581, with daily monitoring	• Appropriate override • Probable ADE • Occurrence of ADE: ICU • Severity: serious • Non-preventable
Allergy	• Vancomycin – Red man syndrome • Ordered vancomycin with directions to infuse over 6 hours • Override reason: "Patient has taken previously without allergic reaction/patient has tolerated previously" • Development of red man syndrome/patchy macular rash despite infusion over 6 hours	• Inappropriate override • Definite ADE • Occurrence of ADE: ICU • Severity: significant • Preventable
Geriatric	• Clonazepam • 1 mg twice daily • Desaturation on floor, requiring readmission to ICU	• Inappropriate override • Definite ADE • Occurrence of ADE: Floor • Severity: life-threatening • Preventable
Geriatric	• Clonazepam • 1 mg three times daily • Home medication • Increased lethargy; clonazepam changed to as needed dose	• Inappropriate override • Definite ADE • Occurrence of ADE: ICU • Severity: serious • Preventable
Geriatric	• Fluphenazine • 5 mg three times daily • Somnolence attributed to medication	• Inappropriate override • Definite ADE • Occurrence of ADE: ICU • Severity: serious • Preventable
Renal	• Glyburide • 5 mg daily • Home medication • Development of acute kidney injury; blood glucose readings of 61 and 49, requiring administration of dextrose and juice	• Inappropriate override • Definite ADE • Occurrence of ADE: ICU • Severity: serious • Preventable
Renal	• Hydrochlorothiazide • Home medication • Elevation of serum creatinine by 0.6 within 48 hours and decreased urine output; potential other causes of elevation	• Inappropriate override • Probable ADE • Occurrence of ADE: ICU • Severity: significant • Preventable

ADE = adverse drug event; ICU = intensive care unit

Figure Legends

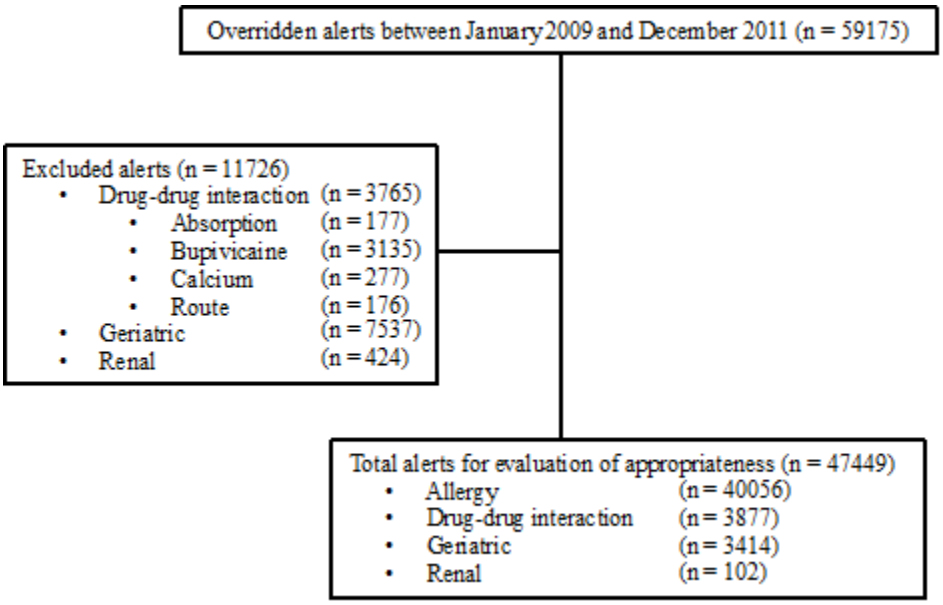

Figure 1. Screening and Inclusion